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# FORECASTING FREEPORT-MCMORAN STOCK PRICE USING *LOCALLY STATIONARY WAVELET*

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**Abstract**

PT Freeport Indonesia is the manager of the Grasberg Mine in Papua, Indonesia, which is one of the largest gold mines in the world. This mine also contains copper and silver for the world market. Freeport McMoRan's shareholder has recently trending topic because its shares have been purchased by the Indonesian government. This stock price value has a very high volatility and tend not stationary. Wavelet transformation is capable of representing functions that are not smooth or have high volatility. Locally Stationary Wavelet (LSW) is a forecasting model by minimizing error values and capturing most of the time series data information. In this research we can get stock price of Freeport-McMoran stationary after differencing. Stock price forecasting using LSW yields a small MAPE value of 1.94%. This indicates that the LSW model is good for forecasting using stock price data.

**Keywords**: Freeport McMoRan, Stasionary, LSW, MAPE

## 1. Introduction

Shares are units of value or bookkeeping in various financial instruments that refer to the share of a company. Usually the stock is sold by the company to the investors. In buying stocks investors should also know about the electability of the company's stock seller, whether the company is worth buying its shares or not. Do not let investors buy shares of a company whose value will be decreased, which resulted if the resale will decrease in value. One look at the electability of a company can be seen from the time coherent data about the stock price of the company. Time series data can be a reference material for us or the investors decide to buy the stock or not.

Freeport has recently become one of the discussions because the shares of PT Freeport Indonesia (a subsidiary of Freeport-McMoRan) have been purchased by the government of Indonesia at 51%, this is certainly a conversation among the stock players in Indonesia as well as in the world.

Some problems in everyday life need to be foreseen before a decision is made, in this case the Freeport-McMoRan shares. Stock data has a very high volatility and tend not stationary. The wavelet transform is capable of representing time and frequency information simultaneously. Time and frequency representations result in wavelet transforms being used to analyze non stationary data. Wavelets are also capable of representing non-seamless functions or functions with high spikes or volatility [3].

[1] introduced Locally stationary wavelet (LSW) as one of the inspired forecasting models of the Non-Decimated Discrete Wavelet. The LSW model can capture most of the information in time series data. [2] developed an algorithm to predict LSW processes with predictors being a linear combination of previous observations with predictor coefficients obtained by minimizing mean square prediction error (MSPE).

To predict $h$ forward step of $X_{t-1+h,T}$ given observation $X_{0,T}, X_{1,T}, \dots, X_{t-1,T}$ is

$$\hat{X}_{t-1+h,T} = \sum_{s=0}^{t-1} b_{t-1-s;T}^{(h)} X_{s,T} \qquad (1)$$

with

$$X_{t,T} = \sum_{j=-J}^{-1} \sum_{k} \omega_{j,k,T} \psi_{j,k-t} \xi_{j,k}$$

According to basic properties of time series where the data to *t+1* is independent of all data from *t=1* but only $p$ last obeservation, then the prediction equation can be written by

$\hat{X}_{t-1+h,T}^{(p)} =$

$\sum_{s=t-p}^{t-1} \sum_{j=-J}^{-1} \sum_{k} b_{t-1-s;T}\ \omega_{j,k,T}\ \psi_{j,k-s}\ \xi_{j,k}.$

(2)

with b is the solution of the local equation of Yule Walker. R program is one of the tools that can be used to forecasting with LSW.

## 2. Method

a. Variable
The variable used in this research is only 1 variable that is Freeport-McMoRan Stock Price.

b. Data source
The data used is Freeport-McMoRan's share price from April 18, 2017 to April 23, 2018. Data is taken from the website id.investing.com.

c. Research Flow
The flow of this research is as follows:
1. Data retrieval
2. Identify data
3. Stabilize the data
4. Forecasting using LSW
5. Calculate MAPE
6. Predict one step ahead

## 3.Results

a. Data Identification

The data modeled is Freeport-McMoRan stock price data taken on id.investing.com. The data is the daily stock price, collected from April 18, 2017 to April 23, 2018 which is denoted by $Y_T$,T=1,2,…,256. Figure 1 below is a data plot of Freeport-McMoran stock price movement:

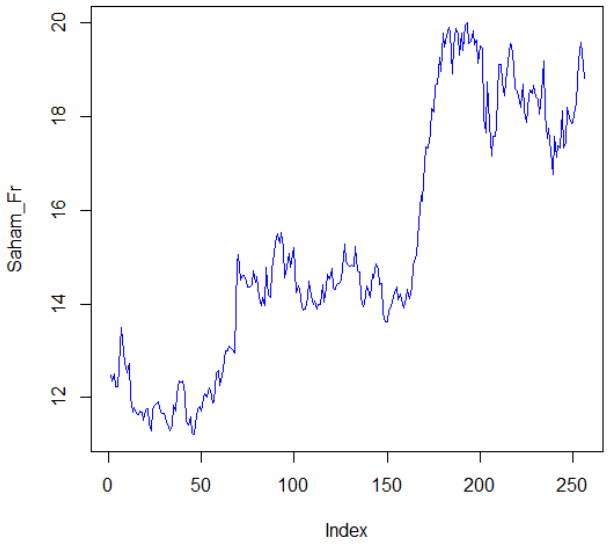


Figure 1. Plot Freeport-McMoRan Stock Price

The figure 1 shows that the data does not contain trend trends, but the movement of data is quite dynamic because of spikes and increases that occur nonlinearly.

b. Stationarity Test

One of the requirements of modeling using LSW is the assumption of stationarity of data must be fulfilled. This research uses Augmented Dickey Fuller test to detect root unit on data causing data unstable. Hypothesis used is $H_0$: there is a root unit (data is not stationary). Using the R program, statistics of Dickey Fuller test (complete output attached) are -2.9428 with p-value = 0.1788. From the value of p value greater than α used is 0.05, it can be concluded that $H_0$ is not rejected which indicates that the data is not stationary.

c. Differencing Data

The stock price data is not stationary according to the ADF test, so it needs to be differenced with the equation $d_t = Y_t - Y_{t-1}, t = 2,3, \ldots, 256$. After the data in differencing obtained plot the following data:

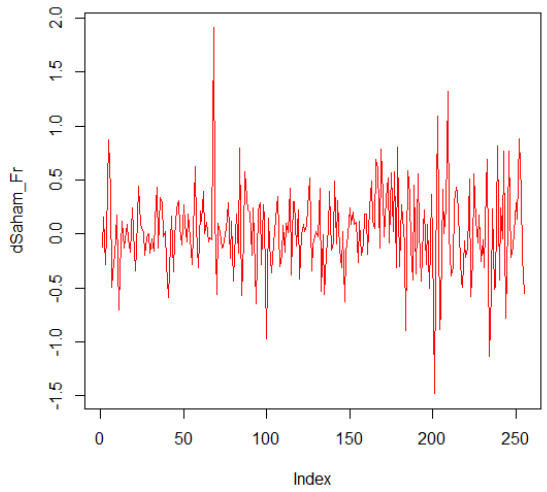


Figure 2. Plot Freeport-McMoRan Stock Price after Differencing

The ADF test of the differencing plot shows that p-value = 0.01, which concludes that the hypothesis of a root unit is rejected. So the data differencing results have been stationary. Furthermore, modeling uses data differencing results. To facilitate the analysis, the T index originally from 2 to 256, made in such a way as t = 1,2, ..., 255.

d. Forecasting Using LSW

The modeling procedure is to predict data t = 41 with data t = 1 to t = 40, then match the result with actual data. Data t = 42 predicted from data t = 2 to t = 41, and so on until 216 (t = 41 to t = 256) predictive data will be matched with actual data. From the way of the modeling, so set h the forecasting step is 1, s is how the data step will take into account the past values of 30 (s requirement is less than a lot of data = 40). Basically the important step of forecasting using LSW is to determine the value of p that is data used to predict data to t + 1. Furthermore, the p value is used to make predictions and obtained prediction results in Table 1 below:

Table 1. Prediction Result (in differencing)

| *t* (according differencing index) | *T* (according actual data index) | Prediction |
|---|---|---|
| 41 | 42 | -0.0095 |
| 42 | 43 | -0.0942 |
| 43 | 44 | -0.0404 |
| 44 | 45 | 0.1452 |
| … | … | … |
| 252 | 253 | -0.0866 |
| 253 | 254 | -0.1412 |
| 254 | 255 | -0.3650 |
| 255 | 256 | -0.1357 |
| 256 | 257 | 0.0161 |

The prediction result is still in differencing form with equation

$$d_{t=41} = d_{T=42} = Y_{42} - Y_{41}$$

then to restore to the actual data is done with the equation:

$$\hat{Y}_{42} = Y_{41} + d_{t=41} = 12.09 - 0.0095 = 12.0805$$

and so on so that the results obtained prediction in Table 2:

Table 2. Prediction Result (in actual data)

| *T* | Prediction |
|---|---|
| 42 | 12.08050 |
| 43 | 11.40582 |
| 44 | 11.37960 |
| 45 | 11.73521 |
| … | … |
| 213 | 19.43426 |
| 214 | 19.37613 |
| 215 | 18.91610 |

e. Goodness of Model Test

Criteria goodness MAPE model based on [4] is calculated using the equation:

$$MAPE = \frac{1}{n}\sum_{T=42}^{215}\frac{|e_T|}{Y_T}$$

Table 3 shows the comparison of actual value and predictive value along with the error.

Table 3. Prediction, actual data, and error

| T | Prediksi | Aktual | Error |
|---|---|---|---|
| 42 | 12.08050 | 11.50 | 0.5805 |
| 43 | 11.40582 | 11.42 | -0.0141 |
| 44 | 11.37960 | 11.59 | -0.2104 |
| 45 | 11.73521 | 11.24 | 0.4952 |
| … | … | … | … |
| 254 | 18.81499 | 19.57 | -0.7550 |

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| | | | |
|---|---|---|---|
| 255 | 19.43426 | 19.36 | 0.0742 |
| 256 | 19.37613 | 18.81 | 0.5661 |

Obtained MAPE value is 0.01946278 or it can be concluded that prediction errors of 1.94% of actual value. MAPE LSW model is relatively small, so it is suspected that the model is good for forecasting. This conclusion is supported by the comparison plot of forecast results and actual data values as in Figure 4 below:

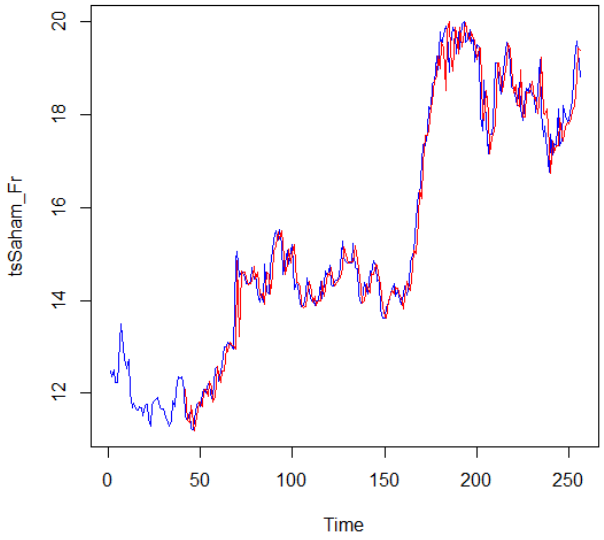


Figure 3. Plot Forecasting and Actual Data

**f. Forecasting one step forward**

Models that have been built show good results, so the model will be used to forecast data one step ahead. Obtained a forecasting value of 0.10609 which shows that

$$Y_{257} = Y_{256} + 0.10609 = 18.81 + 0.10609 = 18.9161$$

So forecasting for one step forward (t = 257) is 18.9161.

**4. Discussion**

Based on the discussion and modeling that has been done, it is concluded that the Freeport-McMoran stock price data is stationary after differencing first order. Forecasting one by one stock price data using Locally Stasionary Wavelet resulted in a MAPE value of 1.94% indicating that the LSW model with s = 30 is good for forecasting using stock price data. Forecast one day ahead of Freeport-McMoran share price of USD 18.91611.

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